Sorting and provenance patterns in the Usumacinta-Grijalva delta, Mexico

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Introduction

During the Holocene, the Usumacinta and the Grijalva rivers have build-up a large delta in the Gulf of Mexico. This delta is characterized as one of the largest beach ridge plains in the world, with well over 500 consecutive beach ridges. Beach ridges are wave-deposited ridges running parallel to a shoreline. This beach ridge plain has the potential to be used as a high resolution palaeo-environmental record since a sequence of beach ridges can be regarded as a time-series for coastal evolution.

River systems

The two main river systems dominating the study area contributed in a comparable amount to the build-up of the delta. Average discharges lie around 1650 m³/s for the Usumacinta and 1000 m³/s for the Grijalva. Peak discharges for both river systems can however exceed 8000 m³/s.





Sediments

The study area is charaterized by a micro wave and micro tidal regime. This leads to the assumption that the (dominant) sediment source for beach ridge formation is fluvial rather than marine. The aim of this study is to determine the relative contribution of the different river systems in the delta.

Method: End Member modelling



Figure 1: LIDAR images (INEGI, 2008) of the study area with coring transects L along a selected beach ridge and the cores taken during the field campaign in 2013 (above) and a close up of transect A and B (below).

Sampling the Delta

Samples were taken from 70 different coring locations at 50cm depth intervals along three transects, with additional corings covering the delta plain. Grain-size parameters were determined according to two methods: sieving (>150 samples) and laser-diffraction particle size analysis (>250 samples).

End Member analysis

Figure 2 A: mean coefficients of determination (r²) for the different End Member models for the entire grain size range and the dominant sediment fraction (Sieve: 75-300µm; Laser 75-354µm). B: individual sediment populations derived from a 4 End Member Model.

Results: End Member abundances



Grain-size distributions are composed of different sediment populations or End Members (EM), which are the result of linear mixing processes such as: 1) mixing of different sediment populations (e.g sediment provenance); and 2) selective mechanisms operating during transport and deposition (e.g. longshore sorting processes). The objective of End Member analysis is to unravel these different sediment populations, without any prior knowledge of the geological system.



Figure 3: different End Member abundances (EM1 = Blue, EM2 = Red, EM3 = Green and EM4 = Purple) along Transect A, B and L, for both the sieve as laser dataset.

Figure 4: identified zones of sediment properties for the Usumacinta-Grijalva delta. Sediments depositis in Zone X find their orgin from the erosion of the old Usumacinta delta promontory.

Conclusions

- EM abundances show clear trends along transects
- EM trends reveal different zones corresponding with different phases of beach ridge formation

- Phases of beach ridge formation indicate shifts in sediment budget and or river position

Further research

This study shows that different sediment populations can be distinguished in the Usumacinta-Grijalva Delta using End Member modelling. This is one of the steps in the reconstruction of the changes in sediment delivery to the Delta. Further research will concentrate on:

- correlating the different transects through time with detailed age-distance models;
 investigating individual beach ridge formation processes;
- determining the influence of longshore and perpendicular coastal sorting processes;

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